Learning to Listen Again: The Role of Compliance in Auditory Training for Adults With Hearing Loss

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Running head: LEARNING TO LISTEN AGAIN: ROLE OF COMPLIANCE

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ABSTRACT

Purpose: To examine the role of compliance on the outcomes of computer-based auditory training with the Listening and Communication Enhancement (LACE^{TM}) program in Veterans using hearing aids.

Methods: Available LACE^{TM} training data for five tasks (i.e., Speech-in-Babble, Time Compression, Competing Speaker, Auditory Memory, Missing Word) from 50 hearing aid users who participated in a larger, randomized controlled trial designed to examine the efficacy of LACE^{TM} training were examined to determine: (1) if there were changes in performance over 20 training sessions on trained tasks (i.e., on-task outcomes); and (2) if compliance, defined as completing all 20 sessions, vs. non-compliance, defined as completing less than 20 sessions, influenced performance on parallel untrained tasks (i.e., off-task outcomes).

Results: The majority, 84% of participants completed 20 sessions, with maximum outcome occurring with at least 10 sessions of training for some tasks and up to 20 sessions of training for others. Comparison of Baseline to Post-Test performance revealed statistically significant improvements for four of seven off-task outcome measures for the Compliant group, with no statistically significant improvements observed for the Non-Compliant group.

Conclusion: The high level of compliance in the present study may be attributable to use of systematized verbal and written instructions with telephone follow-up. Compliance, as expected, appears important for optimizing the outcomes of auditory training. Methods

to improve compliance in clinical populations need to be developed and compliance data are important to report in future studies of auditory training.

Key Words: Auditory Training, Adults, LACE, Hearing Loss, Compliance

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The goal of auditory training (AT) is to increase the listener's ability to compensate for degradation in the auditory signal due to internal (e.g., hearing loss) or external (e.g., noise) factors (Sweetow & Palmer, 2005). The recent development of several computer-based AT programs for at-home use provides potential to increase opportunities for adults with hearing loss to engage in perceptual learning, which in turn may lead to better speech understanding and improved communication ability (Boothroyd, 2007; Sweetow & Sabes, 2007). Systematic reviews of the literature provide evidence that AT can lead to improvements, albeit modest, in speech understanding (Sweetow & Palmer, 2005; Chisolm & Arnold, 2012).

An important question regarding AT outcomes relates to compliance, or adherence, to the treatment regimen. For example, the commercially-available Listening and Communication Enhancement (i.e., LACE) program consists of 20 sessions that are completed over 4-weeks. A review of the clinical records of 3000 patients using LACE revealed that only 30% completed 10 or more of the 20 training sessions (Sweetow & Sabes, 2010). The question arises as to whether individuals who complete LACE's 20-sesssion training protocol (i.e., compliers) have better outcomes than those who do not (i.e., non-compliers). Lack of compliance with non-medication interventions in other areas of healthcare is strongly related to outcomes (e.g., DiMatteo, Giordani, Lepper & Croghan, 2002). It is logical, therefore, to assume that this positive relation exists for LACE use. The present report examines the potential influence of compliance on outcomes of LACE training for adult hearing-aid users. The data analyzed were obtained from a larger study in which the effectiveness of LACE training for Veterans

with hearing loss was examined in a multi-site, randomized-controlled trial (http://www.clinicaltrials.gov/ct2/show/NCT00727337).

Methods

Participants. Fifty Veterans from 58 to 85 years (mean = 66.4 years; SD = 7.6 years) with mean four-frequency (.5, 1, 2 and 4 kHz) RE and LE averages of 46.0- and 47.6- dB HL (ANSI, 2004), respectively, participated. Twenty-four participants were new hearing-aid users (at least 4-weeks of hearing-aid use) and 26 had used hearing aids for at least 6 months. Real-ear verification confirmed the appropriateness of the fits (Byrne, Dillon, Ching, Katch & Keidser, 2001).

On- and Off-Task Outcomes. LACE tracks performance on each of five training modules. Targeted behaviors and measurement metrics for trained tasks (i.e., On-Task Outcomes) are shown in the top panel of Table 1. To assess generalization, parallel untrained tasks (i.e., of-task outcomes) shown in the bottom panel of Table 1 were administered. The measures were: (1) The Words-In-Noise test (WIN; Wilson, 2003); (2) NU No.6 words at 65% and 45% compression (Wilson, Preece, Salomon, Sperry & Bronstein, 1994); (3) a modified NU-20 Competing Message Test (Smith, Wilson & McArdle, 2008); (4) an audio-recorded version of the Digit Span subtest of the Wechsler Adult Intelligence Scale 3rd edition (WAIS-III); (5) Revised Speech-in-Noise test (R-SPIN) in a descending paradigm (Wilson, McArdle, Watts & Smith, 2012). Off-task outcomes were assessed aided in sound field with the loudspeaker at 0°, 1 m from the listener. For speech-in-noise tests, noise was presented at a fixed 70-dB HL level and

speech signals were adjusted to determine the signal-to-noise ratio (SNR) for 50% correct performance (SNR-50). Signals in quiet were presented at 70-dB HL.

Procedure. After baseline administration of the off-task outcome measures, the participants were provided with a laptop computer and high quality speakers, and were given systematized scripted verbal instruction, written step-by-step instructions, demonstrations on the use of LACE, and a template for in-home set-up. Participants were told to complete one session of LACE training daily, 5 days per week, until all 20 sessions were completed. Approximately 48-72 hours after this initial session, the participants were telephoned to confirm that the equipment set-up was successful and that training was underway. Participants were scheduled for post-intervention testing of off-task outcomes 4-6 weeks after the baseline session. During the intervention period participants were encouraged to contact the study audiologist if they experienced any difficulty with the program. Training data were uploaded to the LACE website (http://www.neurotone.com/) to obtain compliance information and on-task performance outcomes.

Results

Compliance. Forty-two of the 50 participants (84%) completed all 20 training sessions and were considered compliant. Three individuals (6%) completed 10 to 19 sessions and five (10%) completed <10 sessions. Of the eight participants, who were considered non-compliant, four were experienced hearing-aid users and four were inexperienced. The Mann-Whitney U test revealed that the compliant and non-compliant participants did not differ significantly on age or pure-tone thresholds.

On-Task Outcomes. In the original study of LACE, Sweetow and Sabes (2006) presented on-task performance as a function of each quarter (i.e., 5 sessions) of the 20 training sessions. Thus, Table 1 shows the scores generated from LACE at the end of each quarter for each task trained, along with the equivalent data from Sweetow and Sabes. Quarter 1 (Q1) training most likely involves procedural learning, with improvements in subsequent quarters reflecting perceptual learning (Sweetow & Sabes, 2006). For the Speech-in-Babble, Time Compression, and Competing Speaker tasks, a lower score indicates better performance, whereas for the Auditory Memory and Missing Word tasks a higher score reflects better performance. Note that for the Missing Word task, the score provided by the current LACE program is in '*LACE Units*,' - a normalized measure with a baseline of 20, for which higher scores indicate better performance. (LACE Units were not used in the Sweetow and Sabes report.) For the current data, separate one-way repeated measures analyses of variance revealed that the main effect of quarter was statistically significant ($p < .000$) for all tasks. Post hoc testing with Bonferroni corrections for multiple comparisons confirmed that performance in Q2, Q3, and Q4 was significantly better than Q1 for all tasks. For Time Compression, Q4 was significantly better than Q3, and for Missing Word, Q3 was significantly better than Q2. Similar to Sweetow and Sabes, the data presented here suggest perceptual learning is occurring, with maximum performance reached somewhere between 10 and 20 sessions, depending on the task. Relative to the data reported by Sweetow and Sabes, individuals in the current study improved more on the Time Compression and Auditory Memory tasks, but improved less on Speech-in Babble and Competing Speaker tasks.

Off-Task Outcomes. To examine the role of compliance on outcomes, the 42 participants completing all 20 sessions were grouped as compliant, and the remaining 8 as non-compliant. Baseline and post-test data for each group on each off-task outcome are shown in Table 2. Results of the Wilcoxon Matched Pairs test revealed significant improvements in performance for the compliant participants for four of the seven off-task outcomes as indicated by the *p*-values. In contrast there were no statistically significant improvements for the Non-Compliant group, however the change scores for the WIN ($p = .058$) Competing Speaker ($p = .072$) tasks approached statistical significance. Given there were only eight non-compliant participants, it is possible the lack of statistical significance was due to being underpowered. Examination of Cohen's *d* effect sizes for dependent samples revealed a moderate effect size for the Competing Speaker task (0.61), but a negligible effect size for the WIN task (0.17) for the Baseline to Post-Test changes for the Non-Compliant group.

Overall, these findings suggest that compliance with the completion of 20 LACE training sessions leads to better off-task performance for understanding rapid speech (i.e., 45% and 65% Compressed Speech). While there also was a statistically significant difference for listening to speech in noise (i.e., WIN) for the compliant participants, the finding of a negligible effect size suggests the change, while reliable, may not be clinically important. Finally, while a statistically significant improvement in performance was found for the Competing Speaker task for the compliant participants, the non-compliant participants also showed improvement. Thus, the Competing Speaker change scores likely reflect procedural rather than perceptual learning.

Conclusions

The present results confirm previously reported data that LACE leads to on-task perceptual learning (Sweetow & Sabes, 2006; Olson, Preminger &), with the greatest improvements occurring between 5 and 10 training sessions. Substantial on-task training improvements often are found in studies of computerized AT (e.g. Burk, Humes, Amos & Strauser, 2006; Stecker et al., 2006), and the on-task outcomes were not surprising. Of greater importance was the high percentage of participants compliant with the completion of all 20 training sessions, and further that off-task outcome for rapid speech improved significantly, with a moderate effect size, for these participants, but not those who were non-compliant. The high adherence rate may be due to the systematized initial training that was provided, which included scripted verbal instructions, written instructions, demonstration, a template for at-home set-up, and a follow-up telephone call. While future research comparing various initial training approaches can confirm the role of a systematization of introducing an AT program on outcomes, the positive on-task and off-task results suggest that it is important to develop methods for improving compliance with training recommendations. The results also suggest that time-on-task is important for optimizing AT outcomes. Finally, all AT studies should report compliance data when interpretation results.

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Table 1. On-Task Performance for LACE™ Training - Present Study and Sweetow & Sabes (2006) data.

Source	Q1	Q2	Q3	Q4
Speech-in-Babble (dB SNR)				
Present Study	6.3	4.3	4.3	4.4
Sweetow & Sabes	6.0	4.6	4.0	3.2
Time Compression (% Compression)				
Present Study	55.6	48.5	48.1	46.9
Sweetow & Sabes	58.0	55.0	53.0	52.0
Competing Speaker (dB SNR)				
Present Study	0.3	-2.6	-3.0	-2.8
Sweetow & Sabes	2.7	1.5	-0.2	-1.1
Auditory Memory (Difficulty Level)				
Present Study	2.7	3.3	3.4	3.4
Sweetow & Sabes	3.7	4.0	4.1	4.4
Missing Word (LACE Units)				
Present Study	20.2	23.1	25.5	27.0

Table 2. Off-Task Performance as a Function of Compliance Group. For Outcomes in dB SNR the "Improvement" was Calculated as "Baseline minus Post-Test Scores" While All Other Improvements were Calculated as Post-Test – Baseline Scores".

Source	Baseline (B) Mean	SD	Post-Test (P) Mean	SD	Improvement	*p*
Words-In-Noise (WIN) (dB SNR)						
Compliant	9.6	2.7	8.9	2.8	0.67	0.007
Non-Compliant	8.9	3.1	9.5	3.1	-0.55	0.072
45% Compressed Speech (% Correct)						
Compliant	73.3	15.3	75.4	15.9	2.10	0.039
Non-Compliant	67.0	10.8	65.3	20.3	-1.75	0.932
65% Compressed Speech (% Correct)						
Compliant	50.4	15.6	55.1	14.6	4.65	0.009
Non-Compliant	47.1	14.6	46.6	15.5	-0.57	0.574
Competing Message (dB SNR)						
Compliant	5.5	4.1	4.6	4.4	0.89	0.000
Non-Compliant	9.2	4.7	6.2	4.9	2.98	0.058
Digit Span Forward (Number)						
Compliant	8.3	1.7	8.3	1.7	0.00	1.000
Non-Compliant	7.9	1.0	8.4	1.1	0.50	0.157
Digit Span Backward (Number)						
Compliant	4.9	1.7	4.9	1.8	0.05	0.710
Non-Compliant	5.9	2.0	4.9	1.6	1.00	0.146
R-SPIN (LP - HP)						
Compliant	4.5	1.8	5.0	1.8	0.50	0.107
Non-Compliant	4.6	1.9	4.7	1.5	0.07	0.833